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INRAE's contribution to the EC's consultation on the European Bioeconomy Strategy: *Towards a Circular, Regenerative and Competitive Bioeconomy*

EXECUTIVE SUMMARY (max. 4000 characters)

INRAE welcomes the European Commission's initiative on the revision of the European Bioeconomy Strategy in light of current social, economic, environmental and geopolitical critical challenges. We share below (and in the attached paper) our views and recommendations.

1. Recognising bioeconomy as a highly complex socioeconomic system implies deploying systemic approaches and carefully considering environmental, economic and social impacts and trade-offs. Some of the major concerns should be highlighted in the EU revised bioeconomy strategy are:

- Integrating bioeconomy under a global agroecology framework, rather than just regenerative agriculture

- Considering bioeconomy-related socio-economic dynamics at the territorial level by deploying bioeconomy projects tailored to local resources and compatible with ecological transition.

- Empowering primary producers and rural actors and actively involve them in the co-construction and decision-making processes related, including via citizen science approaches.

- Integrating biomass production for bioeconomy in general and not only for food production into strategic objectives of the Common Agricultural Policy and other relevant policies; support local biomass processes and scale-up at local levels by investments in pre-industrial and industrial scale infrastructure and supporting low-tech processing

- Ensuring biomass availability thanks to the assessment and the modelling of biomass flows and stocks at local scales

- Favouring biomass efficient use by developing new methods of assessing the transformation processes efficiency, with relevant evaluation criteria and promoting flexibility of uses in a logic of resilience of the European economy-

- **2. R&I as an essential lever for developing the European Bioeconomy.** Research must be supported through a continuum from basic research to scale-up innovations up to market and consumers. In this particular area, special attention should be given in supporting large collaborative multi-actor projects, continuing the Circular Bio-based Europe JU, significantly increase financial support to food systems (an area greatly neglected in the last few years, in particular post-harvest food processing). In order to overcome technological bottlenecks for optimising biomass conversion, the EC should support relevant R&I and not only the technical and economic aspects of scaling up. Bioeconomy and biotechnology interlinks should also be explored, through amplifying R&D funding while rationalising investments and promoting cooperation (e.g. research infrastructures).

3. Facilitating the upscaling and commercialisation of bioproducts and bio-solutions while contributing to EU competitivity, by: i) Streamlining regulation and improving the competitiveness of the bioeconomy; ii) Supporting start-ups and SMEs for scaling of bioprocess innovations; iii) Making room for public-private partnerships to scale-up industrial deployment of bio-based innovations. The

4. Transversal aspects. In order to support bioeconomy sector development in Europe the Commission should also consider: i) Seizing opportunities offered by Artificial Intelligence; ii) Providing a continued investment in building and upgrading skills and (novel) competences; iii) Raising public awareness and understanding of innovations in the bioeconomy.

INRAE, the French National Research Institute for Agriculture, Food and Environment, welcomes the European Commission's initiative on the revision of the European Bioeconomy Strategy. **Contributing to a sober and circular bioeconomy is one of the 5 main scientific objectives of INRAE's roadmap towards 2030**.

Tackling global challenges such as climate change, rapid depletion of natural resources, ecosystem degradation, major loss of biodiversity, combined with a growing population and urbanization - requires finding new ways of producing and consuming goods that respect the different planetary boundaries while ensuring a safe and just operating space for humanity. As bioeconomy helps mitigate the effects of climate change while ensuring food, material and energy security and the well-being of populations, we reckon the importance of its place within the European priorities.

1. Bioeconomy: a highly complex socioeconomic system that requires a systemic vision

Bioeconomy is a concept grounded in the use of renewable biological resources that directly or indirectly result from photosynthesis (animal, plants, microorganisms and biomass derivatives including organic waste). Reflecting the diversity of their sources (including those of the food system), the raw materials and products of bioeconomy are highly diverse, both spatially and temporarily. Bioeconomy thus forms a highly complex socioeconomic system that relies on the successful assessment and reconciliation of food and non-food needs and requirements. **Tackling this complexity and developing bioeconomy requires deploying systemic approaches, most often spatially situated, and carefully considering environmental, economic and social impacts and trade-offs while fostering synergies.**

We highlight below some of the major aspects of the global system that should not be overlooked in the revised EU bioeconomy strategy.

Integrating bioeconomy under a global agroecology framework. Sustainable use of biomass should be conceived considering the preservation of natural resources (particularly soil and water) as well as the new pressures associated with climate change. Sustainability, resilience, circularity, preservation/restoration of ecosystems and biodiversity should be at the centre of the policies related to bioeconomy. Agroecology models for biomass production systems, which promote diversification and adaptation to environmental and socio-economic contexts, are of particular interest. Indeed, while regenerative agriculture concepts focus mainly in resources regeneration (e.g. soils) and carbon capture, agroecology provides a more comprehensive framework, including ecosystem services and social dimensions, with cascading consequences for the entire agri-food system and the development of rural and urban areas.

→ Supporting a semantic shift from regenerative to agroecology-based bioeconomy to highlight more dimensions of the system and give more levers to tackle the complexity of the corresponding challenges.

Considering bioeconomy-related socio-economic dynamics at the territorial level. Bioeconomy is not a simple shift in resources. Developing bio-based products requires the emergence of value chains, manufacturing and social organizations. New stakeholders (or already existing stakeholders with new aims and interest) may get involved. While bioeconomy offers major advantages for local development, it is necessary to analyse the conditions and impacts of its deployment to take the full advantage of its opportunities. Studying the dynamics of producer (e.g., farmers) and consumer behaviors, as well as the role of public policies in accelerating the sustainable development and use of bio-based products are important issues to consider. Unlike the petroeconomy, bioeconomy is well-adapted to a territorial organisation, with each territory being able to exploit its own set of renewable

resources and skills in a manner that is compatible with both local needs, assets and global markets, but also accounting for local social and cultural specificities.

→ Embedding the implementation of the bioeconomy strategy in systemic territorial policies, via the deployment of bioeconomy projects aligned with ecological transition. Spatially explicit simulations are key tools to assess the availability of present and future resources and to test the design of new territorial organizations and evaluate their impacts.

Empower primary producers and rural actors. Primary producers play a key role as providers of biomass. While bioeconomy can contribute to providing them with additional income as well as contributing to job creation, it may participate in tackling the issue of generation renewal in agriculture and forestry and fighting the desertification of rural areas.

→ Fostering active and effective inclusion of primary producers and rural actors in the co-construction and decision-making processes related to bioeconomy deployment in rural areas/territories, including via citizen science approaches.

Policy integration. Sustainable biomass production (from agriculture, forestry, aquaculture) is still insufficiently considered in European and national bioeconomy strategies. Also, while the agricultural sector is central in bioeconomy, a number of related priorities should be included in the next Common Agricultural Policy. This goes hand in hand with the need to consider the market demand, and not being solely focused on primary production.

→ Integrating biomass production not just for food purposes into strategic objectives, in line with the Common Agricultural Policy (CAP), the EU forest strategy, and the EC Vision for Agriculture and Food, keeping in mind the Green Deal objectives.

Assessing and ensuring biomass availability. Biomass availability for emerging multiple bio-based applications (without forgetting food systems) is a major challenge, putting at risk the sustainability and resilience of our ecosystems. If the discussion about land use for food and non-food purpose is an old debate, it is still crucial to puncture biomass with discernment. Therefore, decision on biomass allocation should be made on a science-based multi-criteria approaches and multi-stakeholder decision-making processes.

→ Supporting R&I approaches to modelling biomass fluxes and stocks at nested scales.

Favouring biomass efficient use. Considering that biomass is a finite resource, each puncture has to be carefully thought and any alternative, such as recycling and circularity should be envisioned and promoted if sustainable. An economy based on the sober and circular use of bioresources and the substitution of fossil resources should be promoted. Designing methodologies that support sober and virtuous trajectories and understanding transition processes requires mobilizing a wide range of disciplines, including social sciences and humanities

→ Supporting R&I on new ways of assessing the transformation processes efficiency, with relevant evaluation criteria.

Promote flexibility of uses in a logic of resilience. The bioeconomy strategy should be based on a potentially flexible hierarchy while preserving fundamental uses such as food and feed. Cascading uses must remain a flexible optimisation framework which implies to have a better understanding of raw materials and intermediaries to enable multifunctionality. Flexibility is key to responding to economic, health, and climate contexts and it could be supported with decision-making tools to prioritize the uses

or the development of functional typology of uses based on the different sustainability criteria. Relying on renewable raw materials exposes bioeconomy to seasonal or spatial supply chain variations, but also creates opportunities related to raw material flexibility. Therefore, it is vital that public policy recognises this flexibility, avoiding strict allocation of certain raw materials to certain value chains that generate sector lock-in.

- → Addressing logistics and land allocation issues (including competition between food and non-food uses) for a better mobilization of agriculture and forestry bioindustrial production and biowaste, particularly at regional scales.
- → Eco-designing industrial sectors with a view to the circular economy challenges of energy and water efficiency, based on a spatial and environmental assessment. Tools for transferring knowledge to socio-economic players in support of innovation should be developed.

Supporting local biomass processing. To enhance the creation of value and reinforce European sovereignty, biomass processing should be local. There should be suitable pilot and industrial infrastructures in the territories. The bioeconomy strategy must integrate processing issues to prevent biomass from being exported unprocessed.

- → Investing in pre-industrial and industrial scale infrastructures to underpin local value creation and manufacturing sovereignty, while avoiding damaging exportation of renewable raw materials.
- → Supporting low-tech processing innovation to avoid a possible development gap at the European level
- → Encouraging the scaling up of bioeconomy sectors at the local level.

2. R&I as an essential lever for developing the European Bioeconomy

Research related to bioeconomy must be supported following a continuum from fundamental research to market and consumers. This covers fundamental research to better understand biological mechanisms, but also the entire innovation path from transfer to industrial deployment.

We also see a need for the EU to put various kind of resources (regulatory framework, facilitating tools, etc.) into the process of **coordinating national initiatives**. The outcomes and impacts of research may be amplified through synergies with national programmes such as, for example, the French Plan France 2030 (see Box 1) with massive public investments in research on societal challenges.

Box 1. France 2030 Plan:

Since 2021, the France 2030 Plan has been a flagship initiative of the French government designed to support innovation and its leading actors across the nation. Among other tools, Priority Research Programmes and Equipment (PEPR) and Acceleration Strategies (AS) aim to bolster French research and innovation in strategic scientific fields that are pivotal/crucial to technological, economic, social, health and environmental change. These programs are completed by applied programs with a deployment capacity. As an example, the "*Bioproductions* (PEPR B-BEST): *Biomass, Biotechnologies, and Sustainable Technologies for Chemistry and Fuels*" research program is part of the AS *"Bio-based Products and Industrial Biotechnologies - Sustainable Fuels*". Co-led by INRAE and IFPEN, this program started in 2023 and will run for 7 years, with a budget of 65 M€. The objective is to address the main challenges related to the sustainable conversion of biomass into bio-based products and fuels for a sustainable transition to the bioeconomy and the circular economy. This program supports research on understanding biomass for its sustainable transformation, the development of biocatalysts and processes

using chemistry and biotechnology, as well as supporting transitions through operational environments and digital tools.

A balanced vision is key to maintain the EU's scientific excellence and to expand the knowledge base. It is essential to strike a balance between the production of actionable knowledge and the deployment of innovation, so as not to 'dry up' the innovation pipeline. For reconciling the objectives of production, human and environmental health, life sciences are of paramount importance.

To ensure that Europe remains at the forefront of this major socioeconomic transition it is vital to redress funding levels, focusing on excellent science (funding for Research and Innovation Actions and crucial emerging research European infrastructures such as IBISBA and EMPHASIS), trusted public-private partnerships (e.g., CBE) to accelerate innovation and greater funding synergy. Moreover, considering the new opportunities and challenges that the bioeconomy creates for the food system, it is imperative to increase funding on this area.

In order to optimise biomass conversion and to overcome technological bottlenecks, R&I has a major responsibility. Biomass, due to its structural and chemical complexity, has the potential to generate a wide range of products that can replace fossil-based products or provide new functionalities. However, its intrinsic characteristics make it difficult to exploit. Biotechnologies, for instance, through the development of biocatalytic systems coupled with physical operations, are key approaches for improving biomass transformation and accessing bio-sourced molecules.

→ Supporting at high level R&I on new, efficient and robust transformation processes, on the cascade uses of co-products, the recovery of all types of waste, and the technical and economic aspects of scaling up.

In addition, we should make possible for R&I to explore bioeconomy and biotechnology interlinks. Biotechnology is an intrinsic part of bioeconomy as, unlike chemical technologies developed to use oil, coal and gas, this technology is adapted for the use of materials from biological origin. Nevertheless, the bioeconomy/biotechnology overlap is only partial because biotechnology exists beyond bioeconomy. Moreover, the technology toolbox of bioeconomy extends beyond biotechnology and should include low-tech solutions whenever relevant. INRAE believes that it is crucial to understand and recognise these technology nuances. The potential of biotechnology to empower the bioeconomy has not yet been fully realised and there is a strong need for accelerating the design, construction, testing, and learning cycles, and for the development of more robust microbial ecosystems and biocatalysts. The challenges are to control changes in scale but also to develop original biotechnological processes using microorganisms as cellular factories capable of converting renewable resources into chemical products.

→ Amplifying R&D funding on biotechnology, while rationalising investments, promoting cooperation through instruments such as research infrastructures (e.g., IBISBA) of European importance with the aim of creating a highly competitive European bioeconomy.

3. Facilitating the upscaling and commercialisation of bioproducts and bio-solutions while contributing to the EU competitiveness

Streamlining regulation and improving the competitiveness of bioeconomy. The creation of a more favourable regulatory framework is certainly required to stimulate innovation and spur the delivery of new technologies, processes and products, while favouring the emergence of related EU-based companies and start-ups. One aspect of achieving this is to support risk/benefit analysis with solid scientific evidence.

Support start-ups and SMEs for scaling bioprocess innovations. The EC should recognise and support the crucial role of hybrid entities such as preindustrial demonstrators, as well as research infrastructures, that bridge gaps and mobilise public-private partnerships to nurture the early stages of innovation pipelines. In fact, there is a need to design technological capabilities to support innovation throughout the value chain at different scales.

Making room for public-private partnerships to scale-up industrial deployment of bio-based innovations. The interactions between the two sectors may allow innovation in life sciences to reach the market more rapidly. It could be especially interesting to develop public-private partnerships for pre-industrial demonstrators to de-risk initiatives and investments: co-financing, with public funding for the riskiest upstream part, and private access to demonstration. European and national public-private partnership such as CBE-JU or the French programmes (Ferments du Futur or Carnot Institutes; check Box 2) are good examples for supporting and accelerating R&I translation into market applications.

Box 2. Examples of French public-private partnerships:

Ferments du Futur, is a French public-private partnership gathering 42 members (companies, higher education and research institutions, branch organisations, technical institutes, trade unions and competitiveness clusters). It was launched in 2022 to accelerate research and innovation in ferments, fermented foods and bio-preservation. In 2024, this was supported by the opening of a unique Ferments du Futur Innovation Centre on Paris-Saclay cluster with cutting edge equipment. It has received a funding of 48 M€ for 10 years.

Created in 2006, the Carnot Institutes label aims to develop collaborative research by public laboratories in partnership with socio-economic stakeholders, primarily businesses (from SMEs to large corporations), in response to their needs. There are 34 Carnot institutes bringing together 19,000 researchers from major French research organisations in partnership with private partners, to develop specific initiatives aimed at SMEs and mid-sized companies.

4. Cross-cutting issues

Seizing opportunities offered by Artificial Intelligence. Artificial intelligence (AI) creates considerable opportunities for bioeconomy. Therefore, there is a need to ensure that Europe's data resources (e.g. Available via Eurostat, Copernicus) are interoperable. But AI integration is often hampered by technical complexities, a lack of standardised high-quality datasets for training algorithms, or difficulty in accessing data.

→ By fostering initiatives and policies that make AI accessible, foster collaboration and promote open science and FAIR principles, the Bioeconomy Strategy should accelerate transformative advances across Europe.

Developing skills. The role of research organisations and universities should be recognised in the Bioeconomy Strategy since they educate the next generation of scientists and entrepreneurs. They also provide crucial access to excellence-based research infrastructures and testbeds to validate and scale up new companies.

→ Sustaining investment in building and upgrading skills and (novel) competences, including initial training and long-life learning, namely for farmers and other primary producers (e.g. links to European Skills Agenda).

→ Supporting mobility programmes that allow researchers, students and technical staff to move between countries (e.g. MSCA programme), foster research capacity and therefore improve the creativity, efficiency and quality of research related to bioeconomy.

→ Reinforcing the role of research and innovation infrastructures in testing new ideas and developing prototypes and proofs of concept, as suggested in INRAE's response to the EC consultation on European strategy on research and technology infrastructures,

Raising public awareness and understanding of innovations in the bioeconomy. Innovations linked to life sciences can positively contribute to the development of healthier, safer and more sustainable products and practices in the agri-food sector among others. However, despite various benefits, innovations may generate indifference, reluctance or even rejection from parts of the population. Several factors may explain the possible gap between innovations and public perception, such as distrust of new technologies, political options, cultural habits, misinformation, cognitive biases or past mistakes. It is essential that citizens have a better understanding of the work of scientists. This may apply to all sectors, not only bioeconomy, although the challenge is particularly acute when addressing activities concerning life and life sciences. Bringing research and innovation closer to citizens brings benefits for both society and the research institutions themselves, as it promotes citizens being better informed and science more highly valued. It is important to help the public understand the issues at stake because these are complex subjects that are difficult for non-scientists to grasp. To improve the acceptability of biotechnology, it is necessary to better understand consumer / civil society concerns and reactions regarding these novelties and to highlight some possibilities allowing compensation for this reluctance, including though education and dissemination of knowledge.

→ Deploying a scientific dissemination programme coordinated at EU level, capitalising on existing tools and actions such as those implemented in some Horizon Europe projects (open and participatory science activities, living labs, etc.).

→ Disseminating of scientific information through social media (SoMe) to promote connectivity within the scientific community, overcome barriers to access to sources, increase debate, and reveal layperson perspectives and preferences. The general principles guiding dissemination of professional information via SoMe must remain in line with the general principles of ethics, deontology, and scientific validity that guide science.